ENRG 56 - Building Envelope Systems

COURSE DESCRIPTION: Fundamentals of building envelope systems and how they can be used to control heat, light, sound, moisture, air movement. Benefits, challenges and applications of low-impact sustainable strategies for buildings.

30 Hours (24 lecture, 6 lab)

LEARNING OUTCOMES:

- Describe and distinguish the elements of the building envelope, including roof, walls, and glazing
- Describe and identify various building materials used in constructing commercial buildings
- Estimate the U-value, R-factor and C-value of various insulation materials
- Interpret relevant codes and code compliance related to existing buildings
- Describe the processes of air infiltration and natural ventilation into a building
- Describe various glazing types and relate them to thermal effects
- Compare and contrast various passive heating and cooling systems
- Evaluate the benefits and challenges of implementing various sustainability strategies

COURSE TOPICS:

I. Introduction to building envelope concepts
   A. Elements of buildings as systems
   B. Role of building elements in controlling heat, light, sound, moisture, air movement
   C. Gathering information about existing buildings
      1. Blue prints and as-built drawings
      2. Building employees
      3. Online resources for existing and new buildings (standards & codes)
      4. On-site resources (building plans)
   D. Codes governing buildings
      1. Title 24
      2. UBC
      3. ADA
   E. How and why auditors inventory and describe building envelope elements
      1. Common terminology
      2. Common software used for inventory and calculation

II. Building elements
   A. Roof systems
      1. Exterior finish/color
      2. Exterior insulation type
      3. Performance characteristics
         a. U-factor
         b. R-value
         c. C-value
         d. Heat capacity
         e. Minimally code compliant
   B. Exterior wall systems
      1. Exterior finish/color
      2. Exterior insulation type
      3. Interior insulation type
      4. Overall R-value
      5. Performance characteristics
         a. U-factor
         b. Heat capacity

c. Minimally code compliant

C. Ground floor systems
   1. Exposure
      a. Earth contact
      b. Over conditioned space (adiabatic)
   2. Interior finish
   3. Construction material type
   4. Exterior or cavity insulation

D. Fenestration, glazing and window assemblies
   1. Types of windows
      a. Clear glass
      b. Reflective glass
      c. Selective glass
      d. Low-E
      e. Single glazed
      f. Double glazed
   2. Thermal effects of windows
      a. Conduction
      b. Convection
      c. Radiation
      d. Air infiltration
   3. Window position, dimension and quantity
   4. Exterior window shades and blinds
      a. Fins
      b. Overhangs
   5. Tools for identifying types of glass

E. Interior construction
   1. Ceilings
      a. Interior finish
         1.) Lay-in acoustic tile
         2.) Dry wall
         3.) Plaster
      b. Bat insulation
         1.) No bat insulation
         2.) R-13 Bat
   2. Floors
      a. Interior finish
      b. Construction material type
      c. Concrete cap
      d. Rigid insulation
      e. Slab penetration wall plane
      f. Slab edge finish
         1.) Aluminum
         2.) Asphalt pavement or weathered
         3.) Brick
         4.) Concrete masonry unit (CMU)
         5.) Concrete
   3. Doors
      a. Door type (wood, glass)
      b. Door properties
      c. Dimensions

F. Skylights
   1. Location (rooftop)

2. Amount of daylight provided
    a. Number of skylights
    b. Percentage of roof area
    c. Dimensions
    d. Glazing type

III. Infiltration of building envelope
- A. Shell tightness
- B. Perimeter zones
- C. Core zones

IV. Natural ventilation
- A. Ventilation design principles
    1. General ventilation
    2. Make up air
- B. General comfort and dilution ventilation
    1. Quantity of supplied air
    2. Air supply methods
    3. Mixing air distribution
    4. Displacement ventilation system
    5. Localized ventilation

V. Passive heating and cooling systems
- A. Passive heating
    1. Sun tempered
    2. Direct heat gain
    3. Indirect heat gain
    4. Isolated heat gain
    5. Crossway passive heating
- B. Passive cooling
    1. Passive cooling techniques
        a. Solar chimneys
        b. Thermal
- C. Mass
- D. Ventilation
- E. Roofs
- F. Ponds
    1. Solar shading
    2. Reflective roofs
    3. Cooling tower
    4. Earth tubes
    5. Reflectors

VI. Role of roof, wall and window assemblies in buildings
- A. Low-emissivity
- B. Low-impact
- C. Soundproof

VII. Building envelope sustainability strategies
- A. Common, low-cost energy efficiency measures (EEMs)
    1. Create thermal barriers between indoor and outdoor or unconditioned environments
        a. Caulk or seal air infiltration points
        b. Weatherstrip operable doors and windows
        c. Add blow-in or additional insulation
        d. Install radiant barriers when re-sheathing
    2. Maximize natural light
        a. Add skylights
        b. Install daylight controls to reduce lighting energy

3. Reduce cooling needs
    a. Add radiant barriers when re-sheathing
    b. Resurface roof with white "cool" roofing
    c. Add reflective film to glazing (windows, skylights, glass doors)
    d. Construct exterior shading
    e. Add trees to provide shade
    f. Install white, reflective interior blinds or shades

B. Benefits of implementing EEMs
    1. Energy use reduction and lowered carbon footprint
    2. Occupant satisfaction
    3. Community benefits of low-impact buildings

C. Challenges to implementing EEMs
    1. Cost of installation
    2. Time of cost recovery or return on investment

TYPES OF ASSIGNMENTS:

I. In-class
    A. Class discussions and demonstrations
    B. Interpret building blue print from on-line and client's resources
    C. Small group assignments such as identifying characteristics of doors and windows in an existing building, or locating areas of air infiltration using diagnostic tools
    D. Calculate R-value, C-value and U-factor of various insulation materials
    E. Calculate fenestration of existing building
    F. Possible field trips such as to the Pacific Energy Center, or various buildings on or off campus

II. Out-of-class
    A. Conduct on-line research of codes and regulations for various building materials
    B. Analyze ventilation and infiltration of an existing or new construction building, and prepare a brief report (2-3 pages) of findings
    C. Conduct passive heating and cooling calculations
    D. Written paper (2-5 pages) on topics such as the benefits of passive heating and cooling, or the role of skylights in decreasing energy consumption

TEXTBOOKS & RESOURCES:

- Instructor generated handouts

BEST Center Curricula, Resources & Recordings

Academic Programs
Georgia Piedmont Technical College - Building Automation Systems
Milwaukee Area Technical College - Sustainable Facilities Operations
Laney College - Commercial HVAC Systems
City College San Francisco - Commercial Building Energy Analysis & Audits

Professional Development Materials, Presentations & Videos
National Institutes
Building Automation Systems Instructor Workshops
Webinars (e.g., BEST Talks)

Faculty Profile Videos
Reports & Case Studies
Marketing Resources

BEST
Building Efficiency for a Sustainable Tomorrow

NSF National Science Foundation